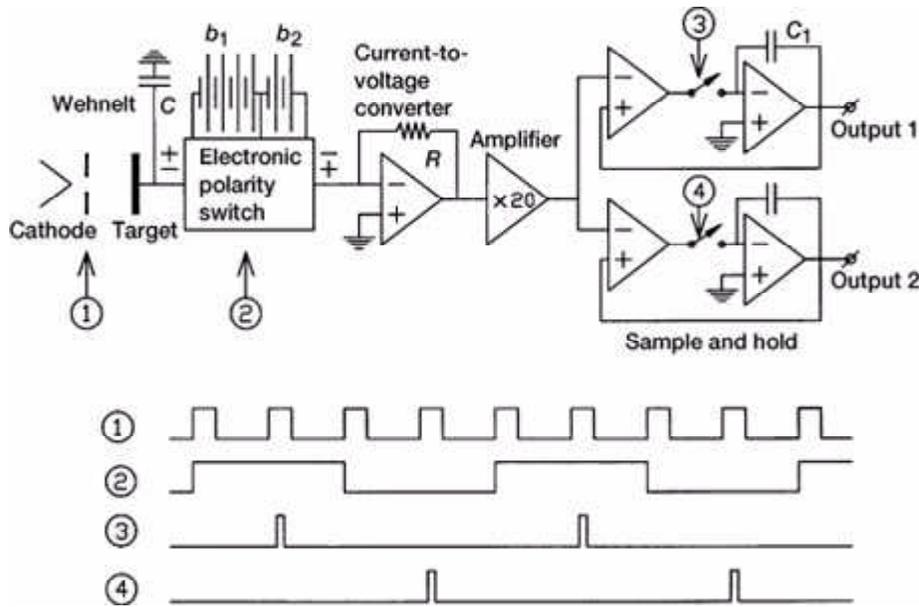


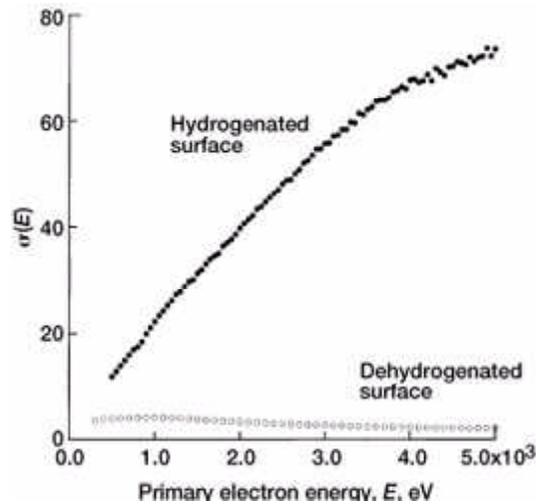
Diamond Analyzed by Secondary Electron Emission Spectroscopy

Diamond is a promising semiconductor material for novel electronic applications because of its chemical stability and inertness, heat conduction properties, and so-called negative electron affinity (NEA). When a surface has NEA, electrons generated inside the bulk of the material are able to come out into the vacuum without any potential barrier (work function). Such a material would have an extremely high secondary electron emission coefficient σ , very high photoelectron (quantum) yield, and would probably be an efficient field emitter.

Chemical-vapor-deposited (CVD) polycrystalline diamond films have even more advantages than diamond single crystals. Their fabrication is relatively easy and inexpensive, and they can be grown with high levels of doping--consequently, they can have relatively high conductivity. Because of these properties, diamond can be used for cold cathodes and photocathodes in high-power electronics and in high-frequency and high-temperature semiconductor devices.

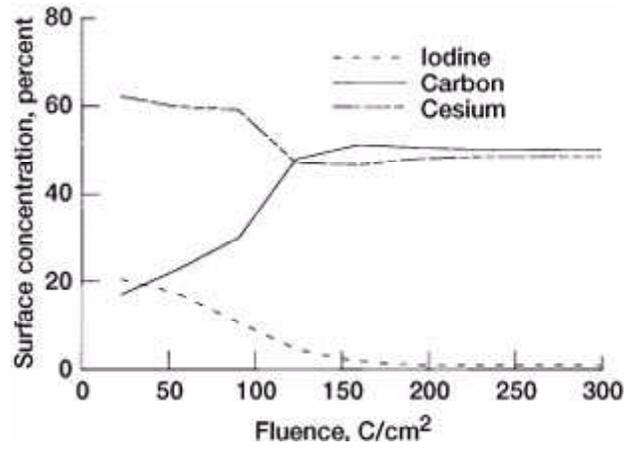


Experimental setup (b, battery; C, capacitor; R, resistor). Top: Block diagram. Bottom: Timing diagram of various voltages supplied into the top drawing.



Secondary electron emission coefficient σ for (100) surface of natural IIb diamond crystal.

Using mostly secondary electron spectroscopy as a tool, the NASA Lewis Research Center conducts research on the electronic properties of both natural diamond crystals and microwave-assisted chemical-vapor-deposited thin diamond films. Whereas artificial diamond films can be made conductive, the effects occurring in natural diamond can be obscured by the undissipated charge. Because of this effect, measurements on natural diamond often have to be done in the pulse mode. The preceding block diagram shows the installation for measuring the secondary electron emission coefficient σ in such a mode, and the preceding graph shows measurements of σ for the (100) surface of IIb natural diamond single crystals, both saturated with hydrogen and dehydrogenated. For the dehydrogenated surface, the secondary electron yield is quite low, especially in comparison to the surface saturated with hydrogen, which has a very high secondary electron yield because of its NEA status. Hydrogen can be desorbed if the surface is heated at elevated temperatures or is exposed to an electron beam. To improve the stability of the surface under an electron beam, Lewis researchers recently studied various coatings that might preserve the NEA property of diamond surfaces. Among the materials tested for the coatings were alkali halides, such as cesium iodide (CsI). Tests showed that as a result of the exposure to the electron beam, the halogen (I in this case) desorbed into the vacuum, leaving the surface coated with a thin layer of active ingredient. The resulting surface was stable under the electron beam exposure and had a very high secondary electron yield, indicating that it was exhibiting NEA. The following graph shows an example of this effect for a thin CsI film on diamond. It can be seen that the iodine concentration at the surface diminishes with the exposure to the electron beam.



Surface concentrations versus fluence for diamond coated with 100 nm of CsI.

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